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TERAVICTA
INVENTION DISCLOSURE FORM

1. Title: Multi-port MEMS strap switch with bi-directional actuation. Docket No. ______

______ Date Rec'd. ______

2. Object of Invention: To provide a multi-port MEMS switch which has gate electrodes which allow both active opening and closing, thereby reducing the susceptibility to stiction

3. Name(s) of Inventor(s): ______ Richard D Nelson

______

4. Date first conceived: REDACTED

5. Previous or planned publication or public disclosure (Attach copy of relevant document):

Publication: Journal______ Report_ Conference or Seminar______ Other______

Title: ______

Name of Publication: ______

Vol. ______ Issue ______ Page ______ (s) Date ______

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6. INVENTOR(S): (I) (We), the undersigned, certify that (I) (We) first conceived the above invention on ______ REDACTED and that it is described in the attached disclosure on pages numbered consecutively 1 through 4

______

Signature in full [illegible signature] Date 3/08/01

Signature in full ______ Date______

Signature in full ______ Date______

7. WITNESSES: We, the undersigned, certify that the invention described in the attached disclosure was explained to us on the date set forth below and that we understand the same.

Signature in full [illegible signature] Date 3/14/01

Signature in full [illegible signature] Date 3/16/01

[For Teravicta Officer Use Only]

8. Suggested Disposition of Invention Disclosure: ______

______

Date ______ Signature ______

Exhibit A

Summary of the invention.

This invention relates to a MEMS switch for DC or RF electrical applications which includes at least three contacts and also a provision for actively opening some of the switch contacts.

MEMS switches are subject to stiction and adhesion when in the closed position, due either to H2O films, solid/solid adhesion, or in some cases residual charging. Generally MEMS switches are activated (closed) by electrostatic action and unactivated (opened) by stored mechanical energy. Standard designs can not be forced open by the same electrode which closes the switch because electrostatic forces between dissimilar charges are only attractive. The design described here is planar, requires no more mask steps than a standard design, and still provides positive opening force at some of the contact points. It consists of a beam (strap) rigidly supported at each end and extending over two actuating electrodes, with three central contact regions on the substrate. One of the contacts is at the center of the beam and the remaining two straddle it left and right. Dimpled contacts on the beam may be positioned to mate with the contact regions on the substrate.

Prior art.

MEMS switches are well known with basic configurations described by Petersen in articles dated 1979 and 1982 and in patents granted in the early '80s on many micromechanical elements and applications. Electrostatically actuated cantilevers and plates were described by Petersen 1982 while a 1980 patent to Hartstein and Petersen (IBM) shows plate structures suspended over electrodes, to be deflected by electrostatics, in a display logic array. Zavracky also holds several patents for cantilever type MEMS switches governing: a method of manufacture, switches with reduced cross section hinges, switches made of dielectric and carrying a conductive button to close an adjacent circuit on the substrate, and simple cantilevers with the actuating electrode protected by a dielectric layer (to avoid shorting).

In short, MEMS devices have been disclosed and/or patented which mimic many of the configurations implemented in larger reed relays or mechanical switches.

US #5,867,302 to Fleming (1999) shows (and claims) a membrane in the form of a doubly supported beam with two gates and at least one contact region. The membrane has built-in stresses which cause it to deform into an S shaped cross section if no actuating voltage is present. A central resilient attachment constrains the membrane to the S shape such that one side (e.g. left) is up and the other is down in response to the stress. This member can deform to allow the beam to assume the required S-shape. Actuation of at least one of the electrodes causes the state to switch to left-down/right-up. Claims cover both electrical switching and mirror applications. All claims require that the membrane be stressed, with the first claim specifically calling out compressive stress.

The patent teaches that the structure is useful for avoiding problems associated with stress or adhesion so long as neither stable state involves contact (i.e.for a mirror actuator or a capacitive switch). It also teaches that the stress-generated shape assures that the switch is bi-stable and remains latched with no actuation power.

Description of the invention.

The invention provides a doubly supported MEMS beam switch structure with two gate electrodes on the substrate and three contact pairs on the substrate and beam. It is shown in Figure 1 and is superficially similar to that of Fleming. It is a strap with three contact dimples and three opposing contact pads. The center dimple is in the center of the beam and the remaining two straddle the center. In the open state, the beam is out of contact with all the substrate pads. If the beam is metal,

or carries metallization, there are 4 available electrical contacts (at the beam and at each pad), making it a 4-port device.

Actuation of one or both of the gates initially causes contact at the central dimple. If both gates are given even higher voltage, contact can be established at all three pads. If only one gate is actuated, contact can be established at the center and at one adjacent pad. If the voltage is now switched to the other gate, the beam switches to provide contact on the other side. Thus, a variety of multi-pole electrical switching states can be established.

In the mode with one gate actuated, the beam assumes an S shape and is thus superficially similar to Fleming. The following differences apply:

1. Fleming requires internal stress to establish the initial state. We do not require or rely upon internal stress for the operation, but our design will also work in the presence of stress.
2. If the internal stress state is tensile, Fleming's implementation will not have the claimed bistable quality. Our implementation will work with either compressive or tensile stress.
3. Fleming requires a compliant center member attached to the beam. We do not require attachment, and in fact do not want it. The central dimple functions during part of the operational sequence as a fulcrum, similar to Fleming, but during other parts it is not in contact at all.
4. Fleming claims a "membrane". The dictionary definition of a membrane involves thinness, but a more technical definition implies that bending stress does not support loads to any significant degree. Our invention functions through the action of bending stress transmitted across the fulcrum between left and right halves of the beam. Thus our device is different from the membranes he claims. This may be academic or it may be useful in dealing with the examiners.

We show a beam in which the fulcrum and central contact is defined by a dimple in the beam. If a planarizing process is used, the fulcrum could be established solely by a sufficiently tall bump on the central pad.

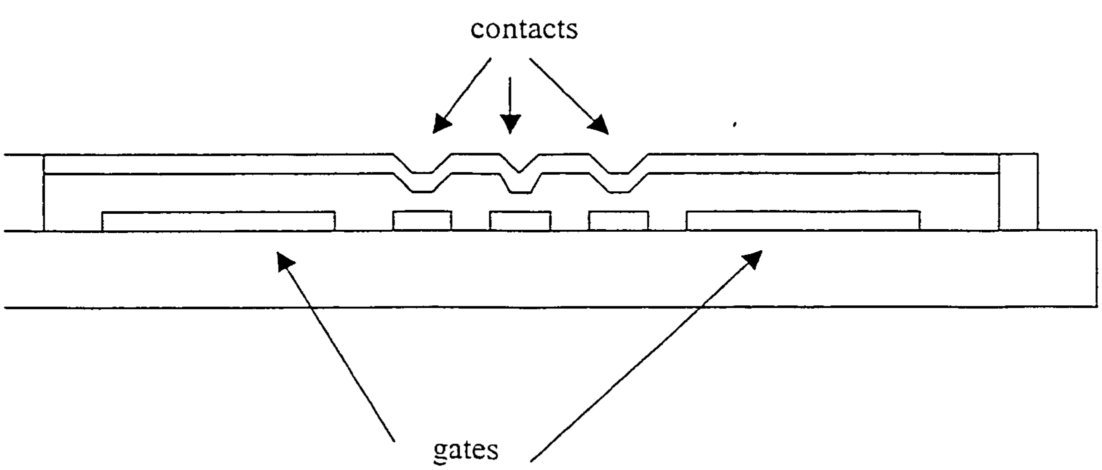

Figure 1. MEMS switch

Claims.

1. A microminiature structure comprising:

a) A substrate,
b) A strap or beam supported at each end above the substrate,
c) A contact region on the substrate located centrally with respect to the beam
d) Two additional contact regions on the substrate located symmetrically with respect to the central contact and disposed along the length direction of the beam,
e) Two actuating electrodes on the substrate, located symmetrically with respect to the central contact and disposed along the length direction of the beam

2. The structure of claim1 wherein:

a) the beam is a dielectric material, and
b) the beam carries metallization at locations opposite one or more of the contact regions

3. The structure of claim 1 wherein: the beam carries metallization at locations opposite one or more of the actuating electrodes

4. The structure of claim 1 carrying the metallizations of claims 2 and 3 disposed to act as an electrostatically actuated electrical switch completing circuits on the substrate between two or more contacts located in one or more of the contact regions on the substrate when voltage is applied to one or more of the actuating electrodes.

5. The structure of claim 2 wherein: metallization at locations opposite one or more of the contact regions on the substrate continues to one or both supports and communicates electrically with metallization on the substrate.

6. The structure of claim 3 wherein: metallization at locations opposite one or more of the gate regions continues to one or both supports and communicates electrically with metallization on the substrate.

7. The structure of claim 1 wherein the beam is constructed so as to carry electricity.

8. The method of using the structure of claim 4 or claim 7 to open and close contacts, composed of one or more of :
   a) applying voltage to one or both electrodes sufficient to close contacts only at the central contact region,
   b) applying voltage to one or both electrodes sufficient to close contacts both at the central contact region and at its first neighboring contact region, but not at its second contact region,
   c) applying voltage at one or both electrodes sufficient to close contacts both at the central contact region and at its second neighboring region, but not at its first contact region.
   d) applying voltage at one or both electrodes sufficient to close contacts at all contact regions.
   e) Releasing all voltage so as to open all contacts.

9. The method of using the structure of claim 4 or claim 7 wherein the central contact region is used as a fulcrum such that actuating one electrode deflects a portion of the beam toward its neighboring contact region and deflects the other portion of the beam away from its neighboring contact region.
10. The structure of claim 1 wherein the contact regions are defined by bumps or pads on the substrate.
11. The structure of claim 1 wherein the contact regions are defined by bumps, pads, dimples or waviness on the beam.